telephony

OCTOBER 8 1979 THE JOURNAL OF THE TELEPHONE INDUSTRY SINCE 1901

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telephony

ISSN 0040 2656

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Published weekly by TELEPHONY PUBLISHING CORP., 55 E. Jackson, Chicago, IL 60604. Telephone 312/922-2435; TWX 910 221 1058.

Officers of Telephony Publishing Corp. are Dan S. Fargo, President; H. D. Fargo, Jr., Vice President and Treasurer; Leo Anderson, L. A. (Jack) Stober, and Ed Robinson, Vice Presidents.

Postmaster: Please send Form 3579 to subscription dept. Telephony Publishing Corp., 55 E. Jackson Blvd., Chicago, IL 60604.

Second class postage paid at Chicago, IL and at additional mailing offices. Single copies (payable in advance) U.S. $2.50 ea., special issues $3.00 ea., issues over 2 years old $3.50 ea. Outside U.S. add 50¢ ea. Subscriptions: $17 one year. Outside U.S. add $9 per year.

Subscription rates apply to employes of operating telephone companies; telephone consultants; contractors; interconnect co's; specialized common carriers; military/govt.; ass'ns.; private communications users; schools/libraries. All others $21 one year. Outside U.S. add $9 per year. Change of address: include old address as well as new address. Attach issue label if possible. Allow 4 weeks for change to become effective.

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Is a satellite toll network feasible for rural telephony?

Small Independent telcos must protect their largest source of revenue—providing message toll service to and from their exchanges. Here's a look at how that can be done

Gerald S. Schrage and John N. Rose

FOR THE average REA (Rural Electrification Administration) financed telephone system, toll revenue accounts for 57% of total revenues. Clearly, small Independent telephone companies need to protect their largest source of revenue—providing message toll service (MTS) to and from their exchanges.

Until recently other common carriers (OCCs) competed mainly in the private line point-to-point communications market. The OCC competition was limited mainly to urban intercity routes and primarily affected the Bell System and some of the larger Independent telephone holding companies. The Bell System, not the OCCs, is the competition in the rural areas. AT&T (American Telephone & Telegraph Co.) and its associated companies through the provision of private line services, private line network services and other alternate services had provided most of the competition to small Independent company message toll services. Even with the Bell competition, toll revenues have grown rapidly.

Now, however, with the introduction of Execunet type services by the OCCs there will be the possibility of increasing diversion of Message Toll System (MTS) traffic and possible subsequent reduction or less growth in MTS revenues for both the large urban based telephone systems as well as the small rural Independent telephone systems. AT&T also is making an effort to compete with the OCCs by offering improved private network service. This spells more competition for the rural based telephone system. Even if the competition to message toll and WATS (wide area telephone service) is not directly in the rural areas, it will indirectly affect toll revenues by lowering or limiting the growth of the toll pool which all telephone companies share.

The direction of the pending legislation in Congress is toward unregulated competition and away from the present regulated environment and its associated uniform toll rates. If these bills become law, toll revenues will generally be reduced more for rural telephone systems.

Because new technology may be applied to reduce costs, the REA decided to look into the possibility of a satellite toll network for borrower central offices. The purpose of the study was to determine if new technology could be applied in rural areas to prevent a raise in toll rates on rural routes if competition and legislation should require deaveraging of nationwide uniform toll rates.

The approach was to find ways of retaining more of the toll revenue on the resultant traffic. Various combinations of satellite and terrestrial microwave trunks were substituted for the present outgoing DDD (direct distance dialing) network and its related Ozark toll settlement procedures. The result is probably what most people already suspected but could not prove; at this time there are few opportunities for the REA borrowers to diversify out of the existing DDD network arrangements to carry MTS traffic. However, the REA borrowers should continue to periodically monitor the situation as the feasibility could change as a result of reduced hardware cost, reduced leased circuit cost, increased services sharing the same facility, increased utilization from imaginative pricing schemes or changes in the toll settlement agreement. Finally, the analysis of MTS traffic diversion will give the telephone company a means of identifying that traffic that might be profitably handled on a point-to-point private line basis for the customer. A detailed analysis leading to these conclusions follows.

Assumptions

Three basic assumptions had to be made before beginning:

1. *Only originating DDD traffic would be carried on the new satellite toll network.* It was assumed that the Bell System would deliver the incoming traffic the same way it does now and would not abandon the toll investment they now have.

2. *All originating satellite traffic would have direct access to all other exchanges in the United States.* At the time of the study we found that it was not cheaper to dial a combination OCC-telco call than to dial a point-to-point telco toll call. The customer will pay more for the com-

Distance	Routing	Cost/Hour
400 miles	DDD	$20.54
400 miles	OCC	≈ $15.00
100 miles	DDD	$17.54
500 miles	DDD	$20.56
500 miles	Tandem*	≈ $32.54

* 400 miles - OCC plus 100 miles - DDD

TABLE 1 *The cost per hour of traffic based on the distance and type of routing.*

GERALD S. SCHRAGE is Chief of the Systems Engineering Branch, and JOHN N. ROSE is Revenue Requirements Specialist for the U.S. Department of Agriculture Rural Electrification Administration, Washington, D.C.

Item	Light Route	Medium Route	Heavy Route
Antenna Size	5 meter	10 meter	30 meter
Capacity	1-5 trunks	50-500 trunks	1000-10,000 trunks
Type Channel	DAMA	PreAssigned and DAMA	PreAssigned
Earth Station Cost (1)	$70K-$95K	$200K-$300K	$3M-$4M
Land, Bldg., O.P. (2)	$50K	$100K	$1M
Total First Cost	$120K-$145K	$300K-$400K	$4M-$5M
Annual Charge @ 20% (3)	$24K-$29K	$60K-$80K	$0.8M-$1M
Annual Lease Ckt (600-1000mi) (4)	$7.2K-$36K	$7.2K-$2.52M (5)	$7.2K-$36M (5)
Annual Lease Ckt (1000-3000mi) (4)	$12K-$60K	$12K-$4.2M (5)	$12K-$60M (5)
Total Annual Charge Range	$31.2K-$89K	$67.2K-$4.28M	$0.812M-$61M

Notes:
1. Earth Station Costs estimated from Comsat and RCA data.
2. Land and Building Cost estimated at $50,000.
   Outside Plant costs estimated at $100/circuit.
3. Annual charge assumed similar to central office equipment.
4. Leased circuit charges based on RCA charges.
5. 30% discount over 50 channels.

TABLE 2 *Earth station parameters and costs.*

bination toll call under present tariffs. Therefore, feasibility could not be based on tandem or through toll switching. Direct access was needed to every exchange (see Table 1).

3. *The results would be compared to the present toll settlements received according to the Ozark plan.* Only the settlements for originating DDD toll would be considered since settlements would remain approximately the same for terminating toll.

Earth stations

The cost of an earth station varies with the channel capacity, antenna size, type of amplifier and receiver and the inclusion of DAMA (demand assignment multiple access). The resultant earth stations usually are either used as light route, medium route or heavy route stations. An Independent telephone company entering the satellite communications field would probably start with a medium route station growing into a heavy route station as the traffic warranted and reusing or selling the displaced earth stations elsewhere. Table 2 lists some characteristics and estimated costs for potential earth stations.

The leased circuit costs can be reduced considerably by leasing transponder space from a satellite owner, especially if interruptible transponders can be used. Typically, COMSAT leases transponders for $1 million/year for interruptible service and $2 million/year for non-interruptible service. Transponders also can be leased in quarter, half and full increments. Assuming 1200 satellite half-circuits per transponder (2 half-circuits per trunk) the annual leased costs are shown in Table 3.

The final stage would be to lease or own an entire satellite by a consortium of Independent telephone companies. Using costs quoted by COMSAT to lease the Comstar satellites, the annual cost would be $16 million per year per satellite for 24 transponders of 1200 half-circuits or 14,400 trunks each.

Potential originating toll revenues were developed by calculating yearly minutes of use of each trunk group size.

The interstate rate per minute for each length of haul adjusted for weekend and night usage was multiplied times the yearly minutes of use to arrive at the originating toll revenues per trunk group (see Table 4).

Net originating toll revenues

Table 5 combines the revenues from Table 4 and the costs from Table 2 plus the ENFIA termination costs to find the breakeven trunk group size. An analysis of the actual toll traffic carried by several typical REA borrowers indicated that the traffic in sufficient usage quantities to consider for diversion

Transponder	#Trunks	Interruptible	Noninterruptible
1	600	$1 M	$2 M
½	300	$0.5 M	$1 M
¼	150	$0.25M	$0.5M

TABLE 3 *Annual transponder costs.*

TABLE 4 *Annual originating MSG toll revenues per trunk group $(000).*

	TRUNK LENGTH					
Trunks	10 Miles	25 Miles	50 Miles	100 Miles	500 Miles	2000 Miles
5	15	30	40	45	50	56
10	48	97	129	145	161	182
15	87	174	232	261	291	329
20	129	259	345	388	431	488
25	173	347	462	520	578	655
30	219	437	583	656	729	826
40	312	625	833	937	1041	1180
50	409	817	1090	1226	1362	1543
75	657	1314	1752	1971	2190	2482
100	912	1825	2433	2737	3041	3447

Note: The interstate rate per minute per mileage band, adjusted for discount period usage, was applied to yearly minutes of use per trunk group developed from traffic busy hour tables.

No. of Circuits	Earth Station & Lease Circuit Costs	Local Termination Costs	Total Costs	Revenues(1)	Net Difference	Ozark Settlements	Net Difference(2)
5	96	7	103	45	(58)	19	(77)
10	132	19	151	145	(6)	61	(67)
15	168	35	203	261	58	110	(52)
20	204	51	255	388	133	163	(30)
25	240	68	308	520	212	218	(6)
30	276	85	361	656	295	276	19
40	312 (3)	110	422	937	515	394	121
50	312 (3)	130	442	1226	784	515	269
75	438 (3)	240	678	1971	1293	828	465
100	564 (3)	340	904	2737	1833	1150	683

Notes:
1. The average length of haul for a toll call for REA borrowers is approximately 100 miles. The interstate rate per minute per mileage band, adjusted for discount period usage, was applied to yearly minutes of use per trunk group developed from traffic busy hour tables.
2. The feasibility is compared to the present Bell System delivery of originating toll. Therefore, the current toll settlements must be considered with costs and originating revenues.
3. 30 percent discount on lease circuits.

TABLE 5 *Annual cost satellite feasibility—earth station at each CO $(000).*

was short haul in characteristic and so from Table 4 the 100-mile length trunk circuit was chosen for analysis. As can be seen in Table 5 for the assumptions made, an Independent telephone company *cannot* enter the satellite trunk network business on a light route basis. Only if the Independent telephone company has a toll trunk group of 30 or more trunks for originating traffic could net revenue increase over what is presently received in the Ozark settlement process. The average REA borrower central office has 15 trunks for originating traffic. This is far short of the needed 30 trunks.

Under a reduced SLU (subscriber line usage) settlement plan even larger trunk groups are needed. The assumption is that under a reduced SLU settlement plan there would be less toll revenue requirements and therefore less toll rates and revenues. An analysis of a reduction of SLU by 20% raises the minimum size of the toll trunk group to at least 40 trunks.

Terrestrial microwave

Since having an earth station at each central office did not prove

Cumulative No. of Central Off.	Cumulative Trunks(1)	Earth Station & Lease C. Costs	Other Costs(2)	Total Costs	Revenues(3)	Ozark Settlements	Net Difference(4)
1	15	168	68	236	261	110	-85
2	25	240	154	394	520	218	-92
3	33	298	213	511	738	310	-83
4	41	312	297	609	952	400	-57
5	48	312	378	690	1151	483	-22
6	54	333	451	784	1334	560	-10

Notes:
1. There are 15 trunks in the average REA borrower central office for originating DDD message toll traffic. As this traffic is combined for satellite transmission, efficiencies are realized and the size of combined group is less than the sum of the individual groups.
2. Included in this column are exchange termination costs based on ENFIA methods, 2GHz digital microwave, switching, and other miscellaneous costs.
3. The average length of haul for a toll call for REA borrowers is approximatly 100 miles. The interstate rate per minute per mileage band, adjusted for discount period usage, was applied to yearly minutes of use per trunk group developed from busy hour traffic tables.
4. The feasibility of the combination satellite microwave system is compared to the present Bell system delivery of originating toll. Therefore, the current toll settlements must be considered with costs and originating toll revenues.

TABLE 6 *Combination satellite—microwave annual cost feasibility $(000).*

feasible for REA borrowers, we then investigated the possibility of several REA borrowers who are in close proximity concentrating their individual toll traffic by means of terrestrial digital microwave radio into a single jointly-owned earth station.

Table 6 expands Table 5 by adding the number of central offices and other costs such as digital microwave and switching to the ENFIA type termination costs. The average REA central office has 15 originating toll trunks and the microwave radio was assumed to be a single hop star configuration into the single earth station site. The results show that traffic from more than six central offices must be concentrated to increase net revenue on the present settlement basis. Given a reduced SLU basis of settlement even more central offices need to be concentrated. With a 20% SLU reduction, the minimum number of central offices is at least seven. There is a point of diminishing return since the more central offices combined the greater the distances and the microwave costs to concentrate the toll trunks at one point.

	TRUNK LENGTH		
TRUNKS	100 MILES	200 MILES	300 MILES
12	-29	-82	-181
24	- 1	-43	- 89
36	33	- 5	- 44
48	63	33	3
60	95	71	48
72	125	109	94
84	156	146	139
96	188	186	185

ANNUAL NET REVENUE POINT TO POINT EXECUNET TYPE SERVICE $(000)

	TRUNK LENGTH		
TRUNKS	100 MILES	200 MILES	300 MILES
12	-25	-78	-138
24	11	-35	- 95
36	46	14	- 53
48	82	38	- 10
60	117	63	32
72	152	88	74
84	188	111	117
96	223	137	159

Note: Costs are for 2 GHz digital microwave routes. Rates are similar to the Bell interstate mileage rate between a category (A) rate center and category (B) rate center.

TABLE 7 *The annual new revenue for special service trunks and the annual net revenue for point to point Execunet type service $(000).*

Net revenue for special services

Since we already had developed the microwave costs, we also decided to study the feasibility of microwave routes for special service and Execunet type services. Rates for special services were based on Bell interstate rates. Consideration was given that the rates would have to be cheaper than Bell's to attract customers. This reasoning also was used for developing Execunet type service revenues.

Approximately 36 trunks are needed for a 100-mile borrower-owned microwave route to provide economically feasible special services or point-to-point Execunet type of service. As the routes get longer, even more trunks are needed to prove feasibility. REA borrowers, in general, have far less traffic than is required to support these types of services on a cost basis. This feasibility does not include the reduction in toll revenues (see Table 7) resulting from customers switching from MTS. □